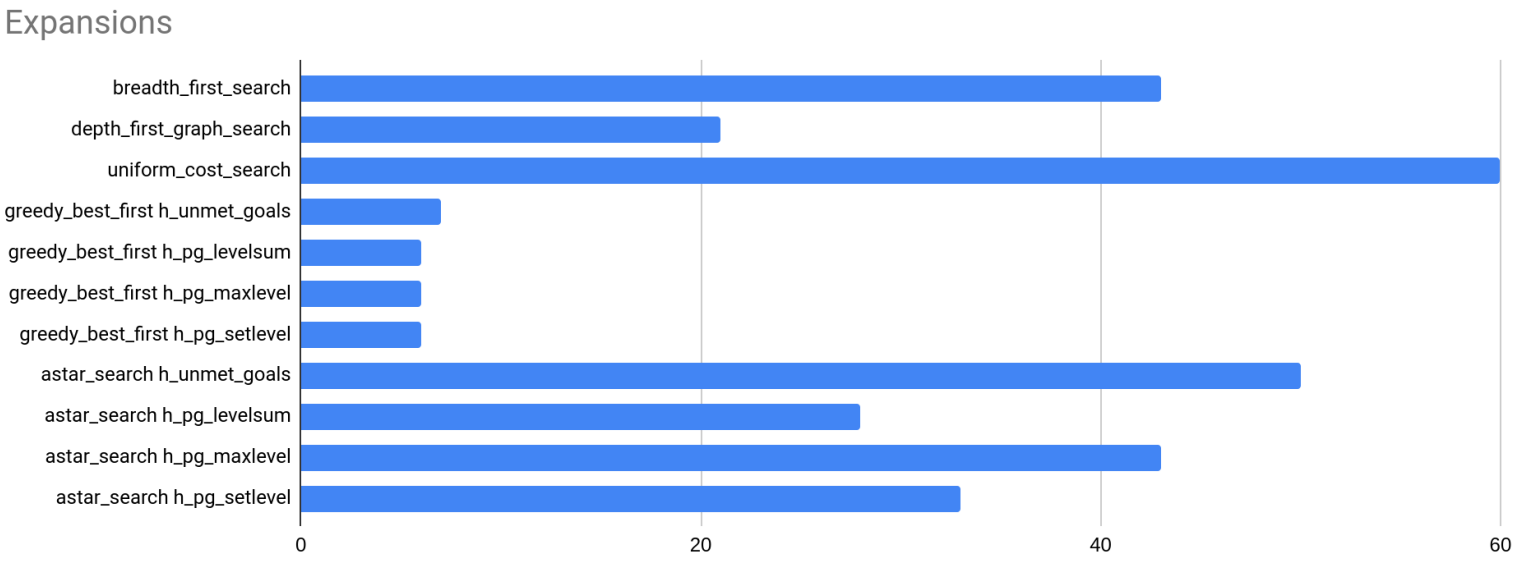
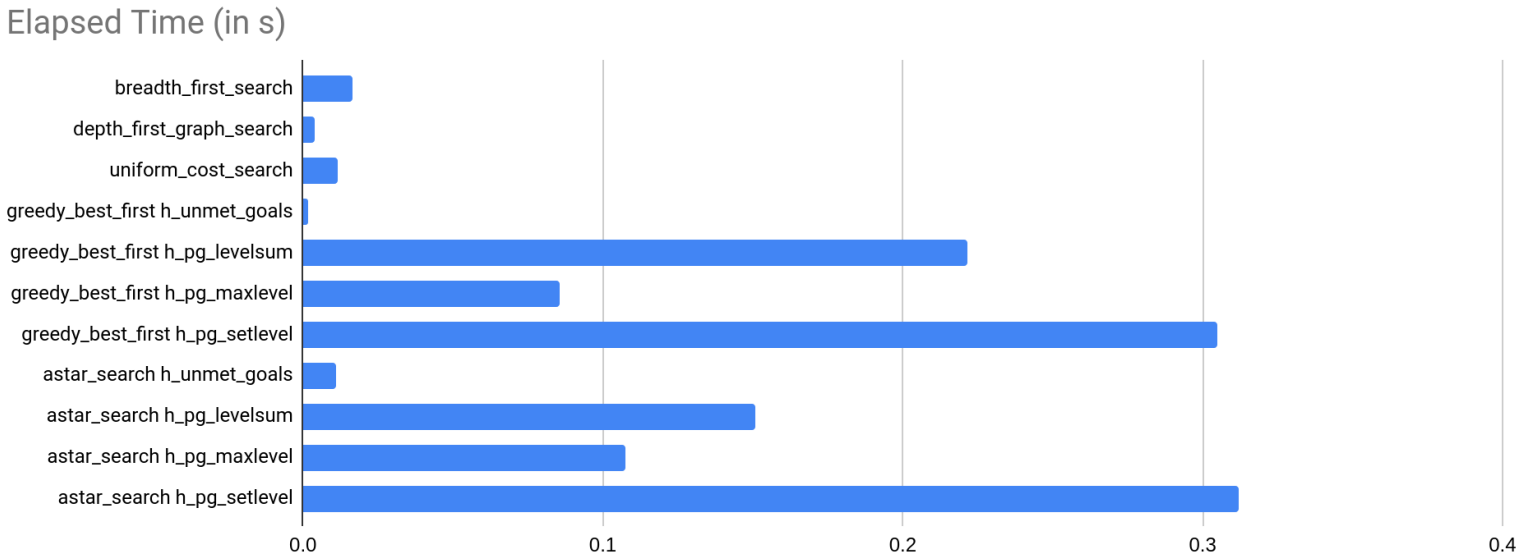
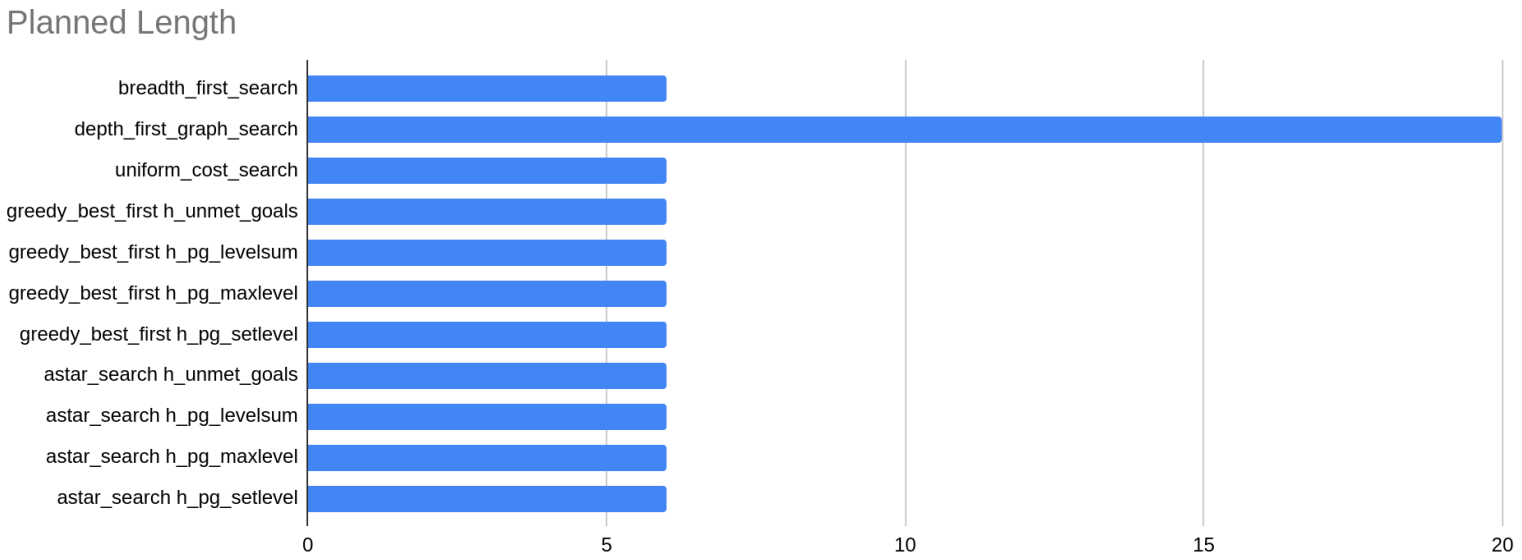
# Classical Planning

## Air Cargo Problem 1

| Algorithm | Actions | Expansions | Goal Tests | New Nodes | Planned length | Elapsed Time |
|---|---|---|---|---|---|---|
| breadth_first_search | 20 | 43 | 56 | 178 | 6 | 0.0165736 |
| depth_first_graph_search | 20 | 21 | 22 | 84 | 20 | 0.004053817 |
| uniform_cost_search | 20 | 60 | 62 | 240 | 6 | 0.011663013 |
| greedy_best_first h_unmet_goals | 20 | 7 | 9 | 29 | 6 | 0.00162189900 |
| greedy_best_first h_pg_levelsum | 20 | 6 | 8 | 28 | 6 | 0.221448701 |
| greedy_best_first h_pg_maxlevel | 20 | 6 | 8 | 24 | 6 | 0.085398933 |
| greedy_best_first h_pg_setlevel | 20 | 6 | 8 | 28 | 6 | 0.305025476 |
| astar_search h_unmet_goals | 20 | 50 | 52 | 206 | 6 | 0.011085351 |
| astar_search h_pg_levelsum | 20 | 28 | 30 | 122 | 6 | 0.150917725 |
| astar_search h_pg_maxlevel | 20 | 43 | 45 | 180 | 6 | 0.107758392 |
| astar_search h_pg_setlevel | 20 | 33 | 35 | 138 | 6 | 0.312191374 |






*Analysis:*

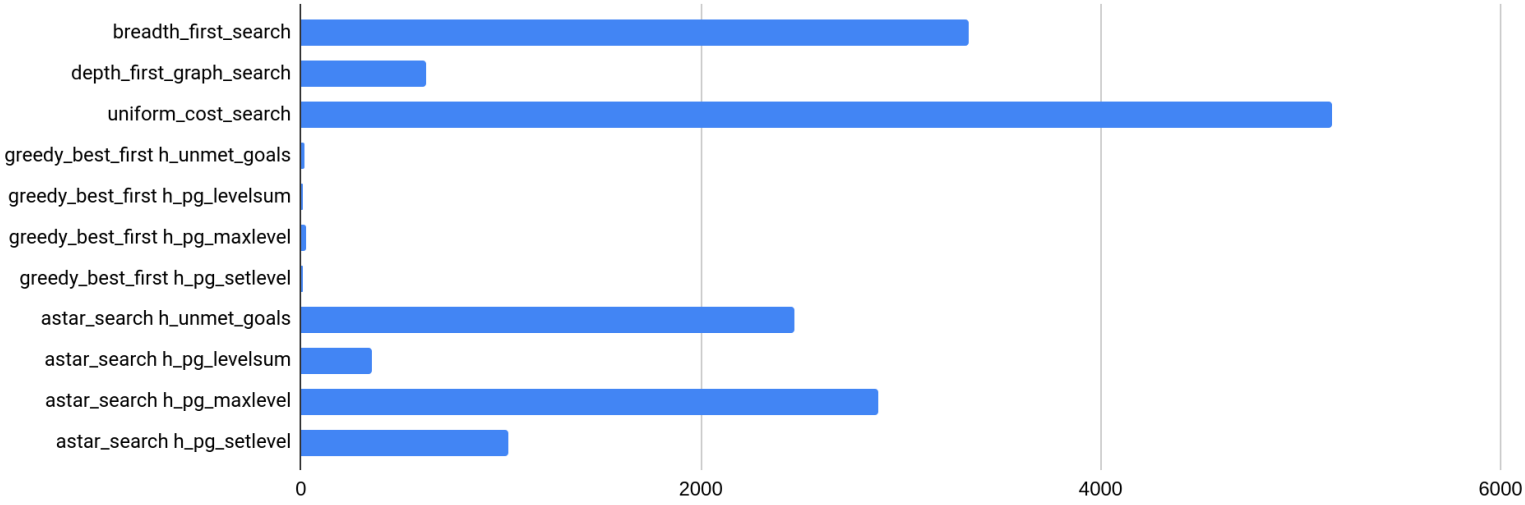
- *Greedy-search had the feast expansion of new nodes*
- *Uninformed search had the best performance*
- *Except for depth-first search, all algorithms had the same planned length*

## Air Cargo Problem 2

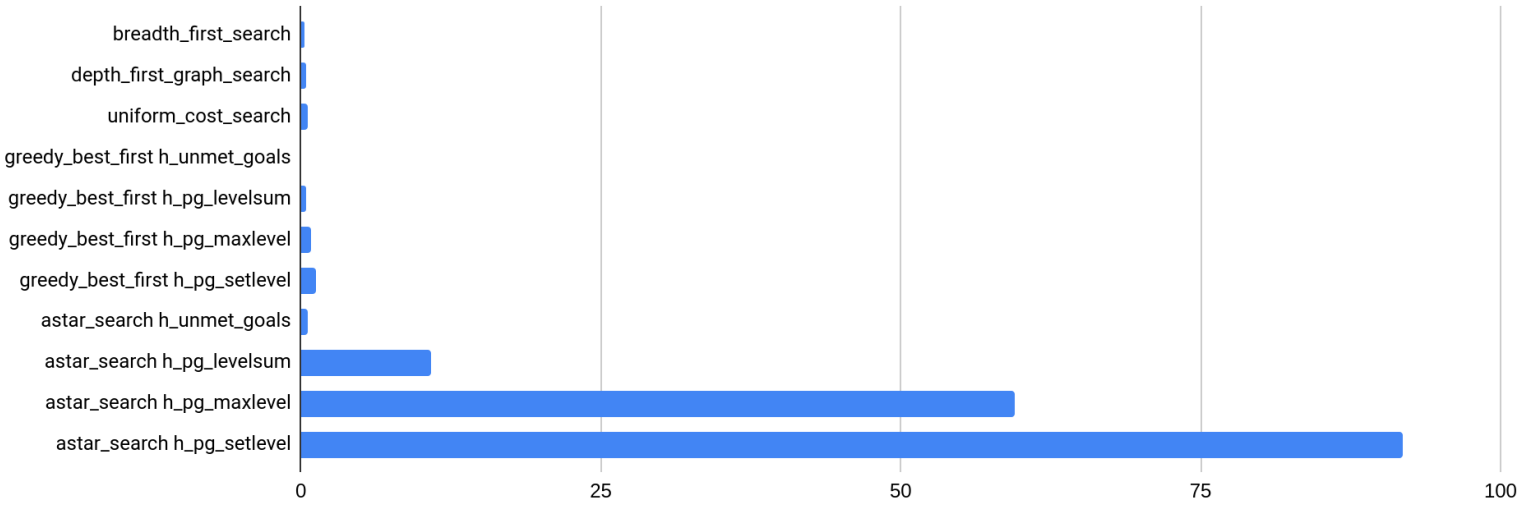
| Algorithm | Actions | Expansions | Goal Tests | New Nodes | Planned length | Elapsed Time |
|---|---|---|---|---|---|---|
| breadth_first_search | 72 | 3343 | 4609 | 30503 | 9 | 0.236146225 |
| depth_first_graph_searc | 72 | 624 | 625 | 5602 | 619 | 0.392530226 |
| uniform_cost_search | 72 | 5154 | 5154 | 46618 | 9 | 0.523219102 |
| greedy_best_first h_unmet_goals | 72 | 17 | 19 | 170 | 9 | 0.01980807 |
| greedy_best_first h_pg_levelsum | 72 | 9 | 11 | 86 | 9 | 0.431646128 |

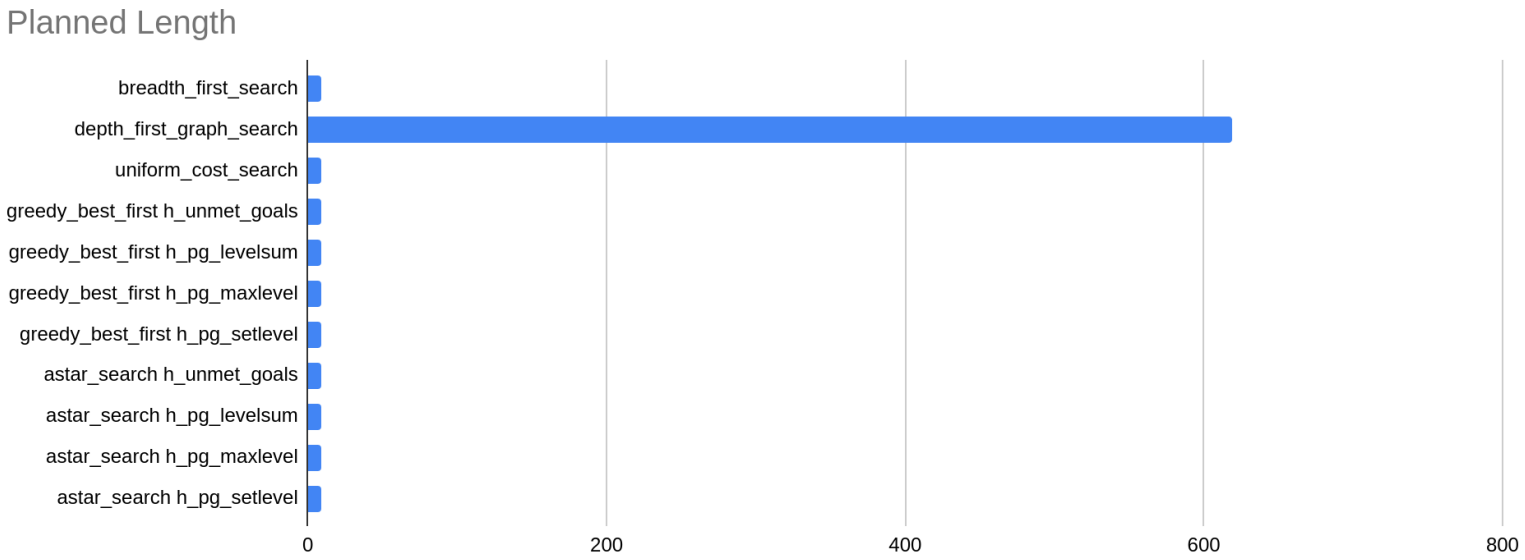
| | | | | | | |
|---|---|---|---|---|---|---|
| greedy_best_first h_pg_maxlevel | 72 | 27 | 29 | 249 | 9 | 0.853740974 |
| greedy_best_first h_pg_setlevel | 72 | 9 | 11 | 84 | 9 | 1.278744719 |
| astar_search h_unmet_goals | 72 | 2467 | 2469 | 22522 | 9 | 0.518309286 |
| astar_searchh_pg_levelsum | 72 | 357 | 359 | 3426 | 9 | 10.81807984 |
| astar_searchh_pg_maxlevel | 72 | 2887 | 2889 | 26594 | 9 | 59.46431371 |
| astar_search h_pg_setlevel | 72 | 1037 | 1039 | 9605 | 9 | 91.89364934 |

## Expansions




## Elapsed Time (in s)



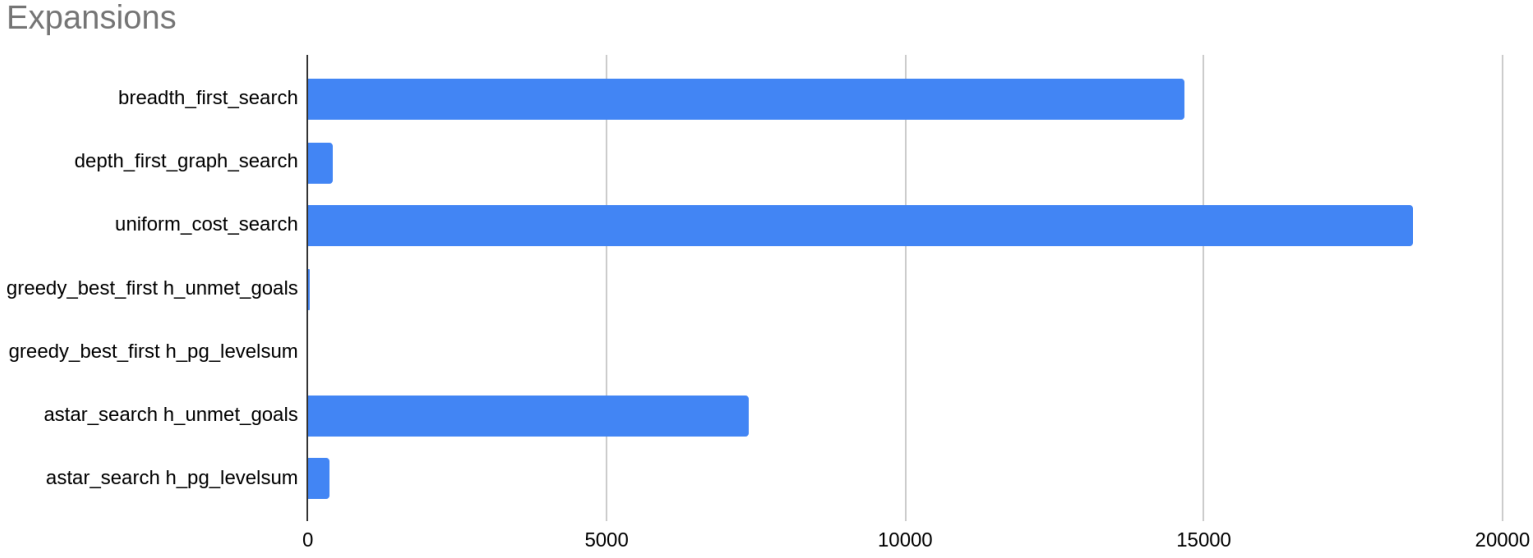


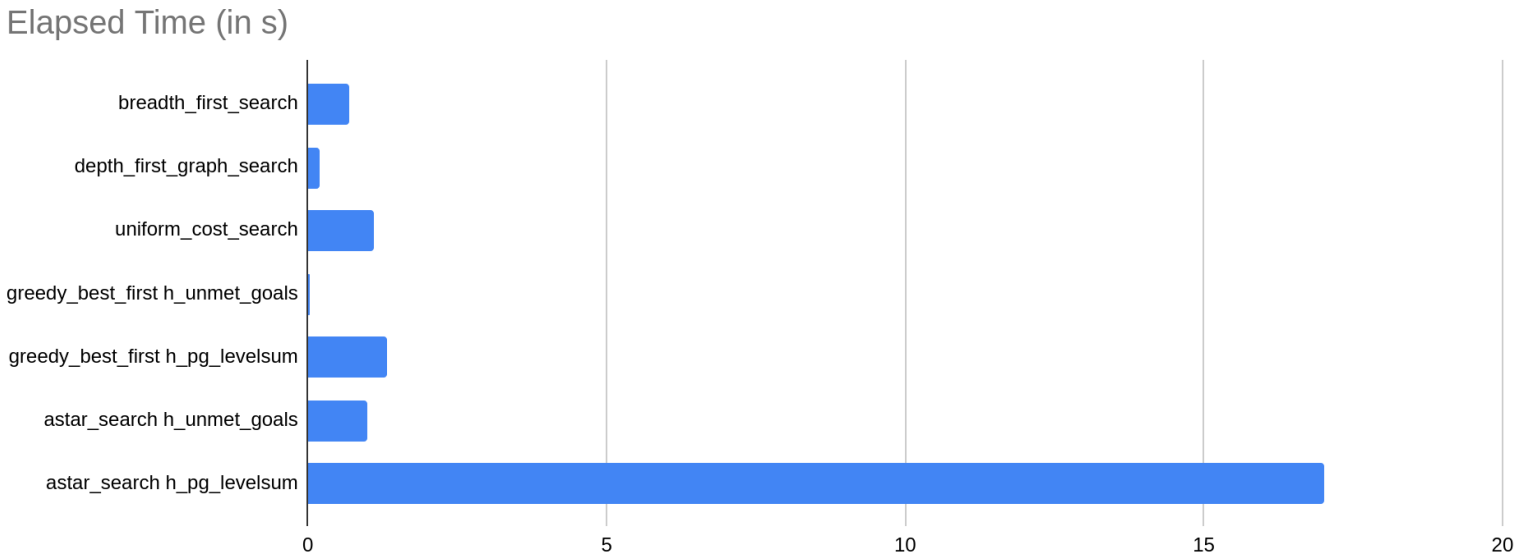

*Analysis:*

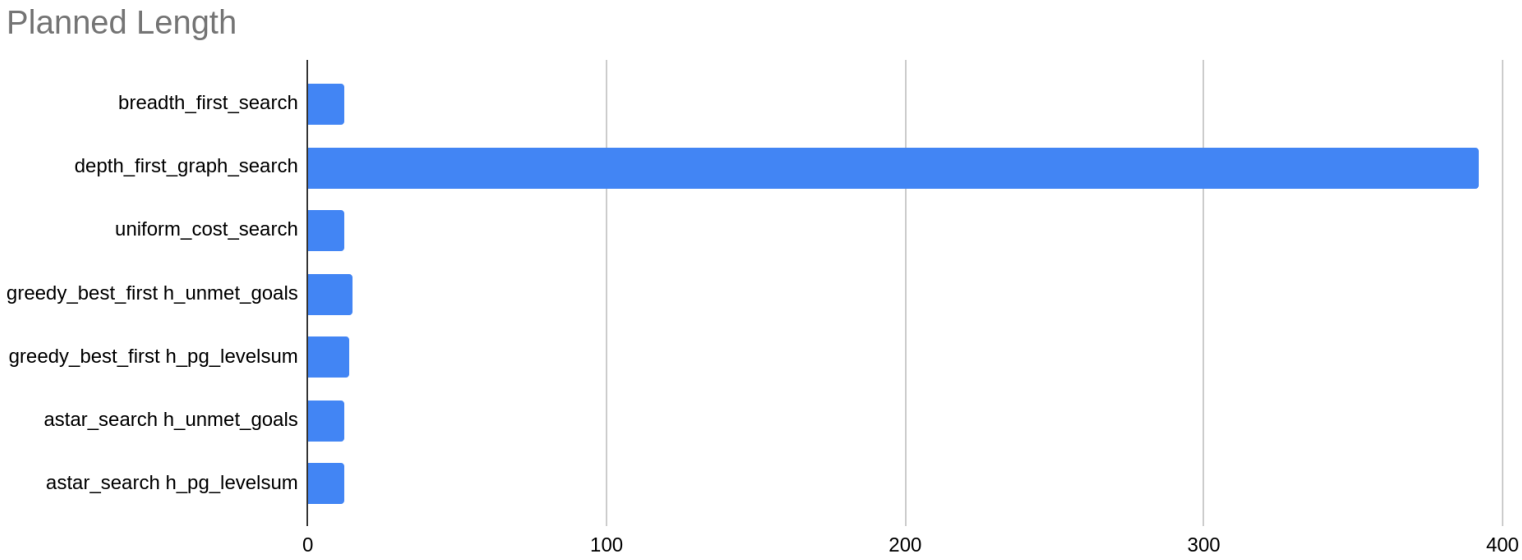
- *Again, Greedy-search had (by far) the feast expansion of new nodes*
- *A-Star search had the worst performance. Uninformed and Greedy search had similar results*
- *Again, Except for depth-first search, all algorithms had the same planned length*

## Air Cargo Problem 3

| Algorithm | Actions | Expansions | Goal Tests | New Nodes | Planned length | Elapsed Time |
|---|---|---|---|---|---|---|
| breadth_first_search | 88 | 14663 | 18098 | 129625 | 12 | 0.678347079 |
| depth_first_graph_search | 88 | 408 | 409 | 3364 | 392 | 0.186356142 |
| uniform_cost_search | 88 | 18510 | 18512 | 161936 | 12 | 1.116633169 |
| greedy_best_first h_unmet_goals | 88 | 25 | 27 | 230 | 15 | 0.023515381 |
| greedy_best_first h_pg_levelsum | 88 | 14 | 16 | 126 | 14 | 1.336863622 |
| astar_search h_unmet_goals | 88 | 7388 | 7390 | 65711 | 12 | 0.980664153 |
| astar_search h_pg_levelsum | 88 | 369 | 371 | 3403 | 12 | 17.00977376 |





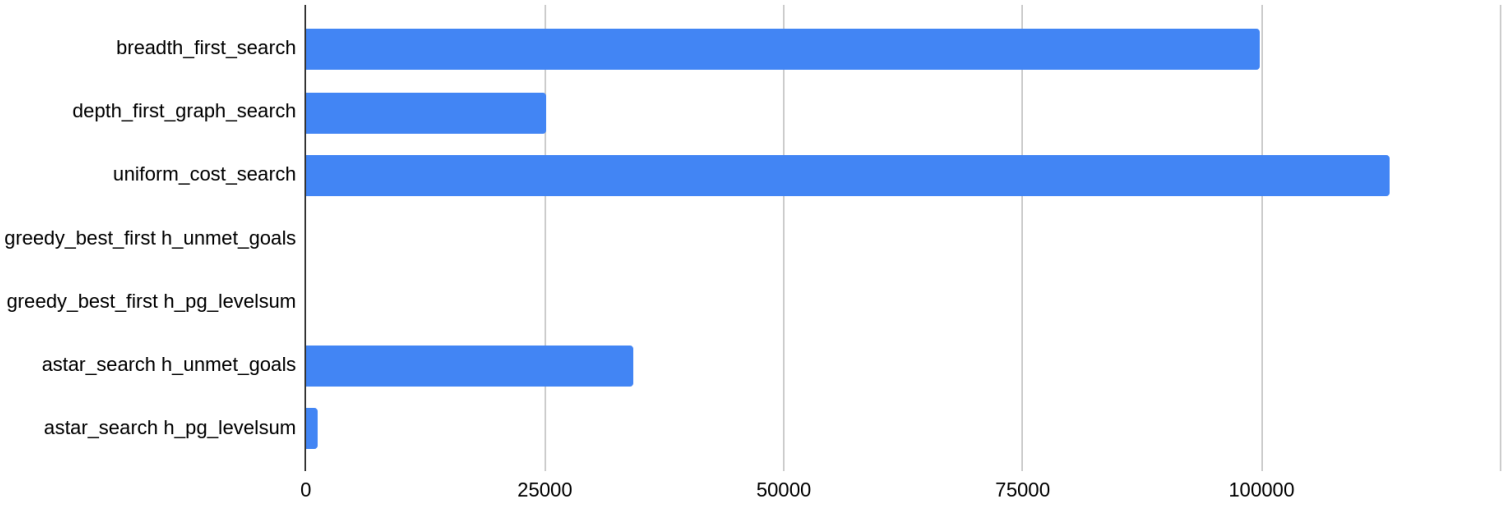

*Analysis:*

- *Again, Greedy-search had the fewest expansion of new nodes. Uninformed search had by far the most overhead*
- *Greedy-search (h_unmet_goals) had the best performance. A-Star (h_pg_levelsum) by far the worst*
- *Again, except for depth-first search, all algorithms had similar planned length with Greedy-search falling behind*

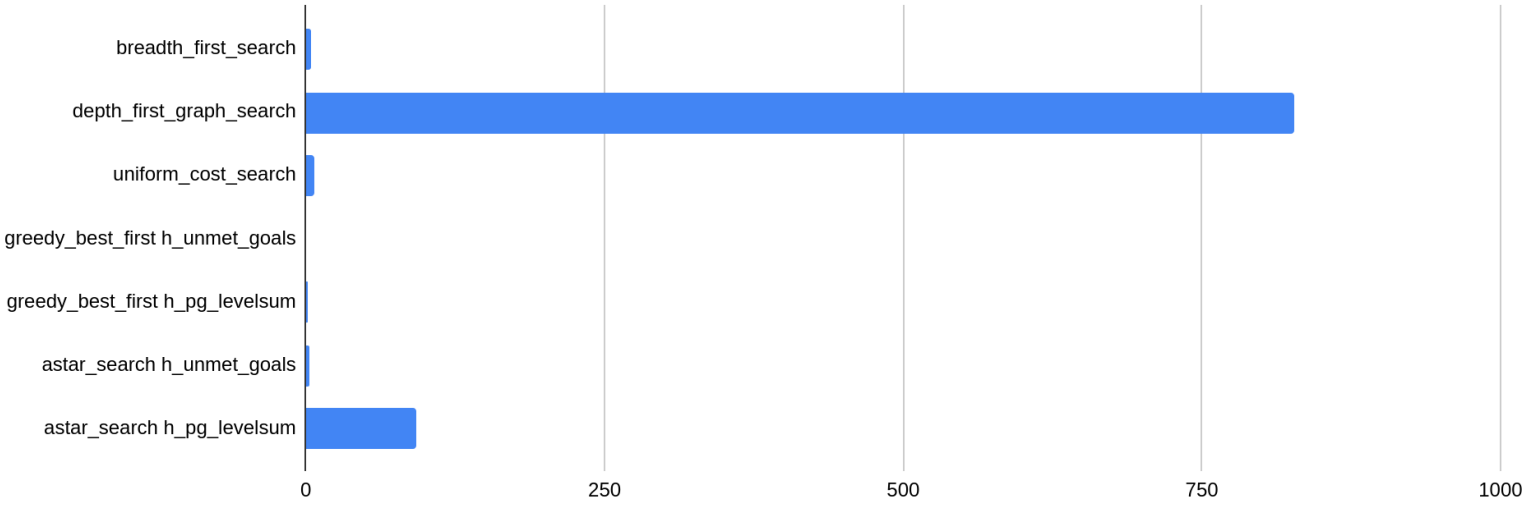
## Air Cargo Problem 4

| Algorithm | Actions | Expansions | Goal Tests | New Nodes | Planned length | Elapsed Time |
|---|---|---|---|---|---|---|
| breadth_first_search | 104 | 99736 | 114953 | 944130 | 15 | 4.664306404 |
| depth_first_graph_search | 104 | 25174 | 25175 | 228849 | 24132 | 827.7768067 |
| uniform_cost_search | 104 | 113339 | 113341 | 1066413 | 14 | 7.138468767 |
| greedy_best_first h_unmet_goals | 104 | 29 | 31 | 280 | 18 | 0.015185867 |
| greedy_best_first h_pg_levelsum | 104 | 17 | 19 | 165 | 17 | 1.602999661 |
| astar_search h_unmet_goals | 104 | 34330 | 34332 | 328509 | 14 | 3.331251817 |
| astar_search h_pg_levelsum | 104 | 1208 | 1210 | 12210 | 15 | 92.18001484 |

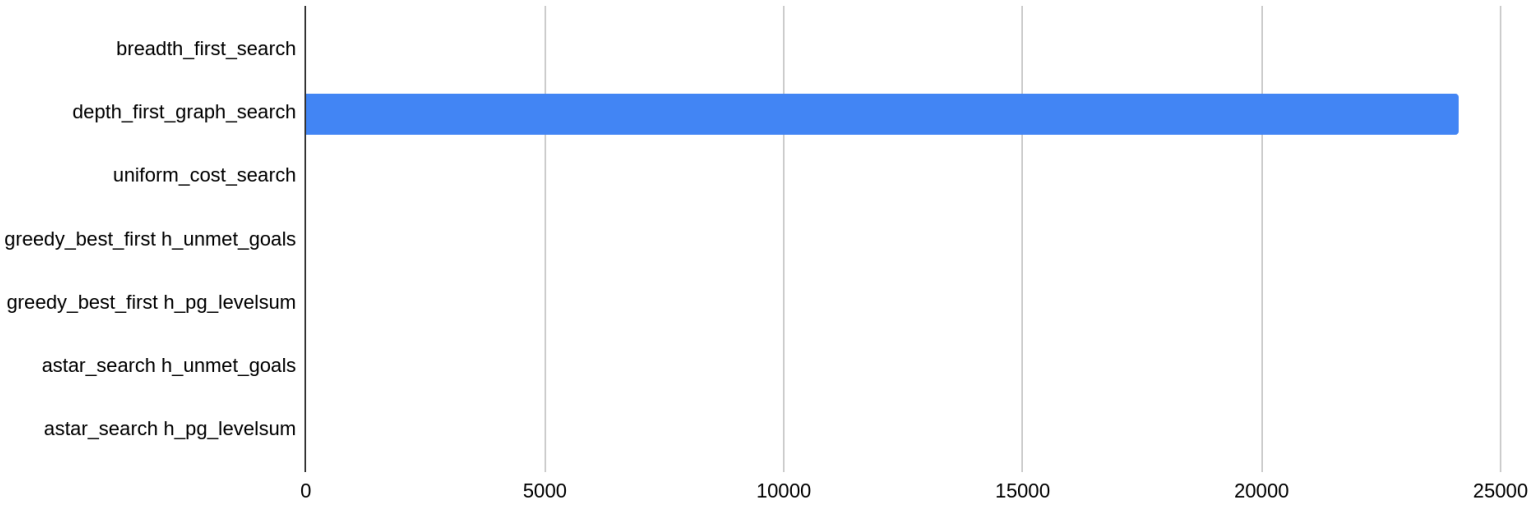
## Expansions




## Elapsed Time (in s)




## Planned Length




*Analysis:*

- *Again, Greedy-search had the fewest expansion of new nodes. Uninformed search overhead increases*
- *Greedy-search (h_unmet_goals) had the best performance. Depth-first by far the worst*

- *Breadth-first, Uniform-cost and A-Star search had the best planned length results*

## Additional Questions

- Which algorithm or algorithms would be most appropriate for planning in a very restricted domain (i.e., one that has only a few actions) and needs to operate in real time?
    - ➡ To meet the requirements of good performance and only few actions, greedy-best-first with h-unmet-goals would be the best match. Depending on the restriction of the domain, uninformed search can be a good choice too.

- Which algorithm or algorithms would be most appropriate for planning in very large domains (e.g., planning delivery routes for all UPS drivers in the U.S. on a given day)
    - ➡ With informed search planning time and computation can rise exponentially with additional complexity. Therefore, it is vitally important to keep planning in very large domains as simple as possible. Greedy-best-first with h-unmet-goals delivers good results as the heuristic is very simple.
      Depending on the domain, uninformed search can be a good choice. However, uninformed search can also result in a considerable amount of useless actions.

- Which algorithm or algorithms would be most appropriate for planning problems where it is important to find only optimal plans?
    - ➡ If optimal planning matters the most, A-Star would be the best choice as it delivers the most reliable results.